InkPhysics

ANSWER BOOK

Telescopes and image formation

Astrophysics · Year 13

AQA 3.9.1.1, 3.9.1.2

11 questions · 32 marks

NAVY EDITION

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SECTION A · Warm-up

A1 The focal planes of the objective and the eye lens coincide, so the final image is formed at infinity and is viewed by a relaxed eye. The tube length is then $f_o + f_e$. [2]

A2 The angle subtended at the eye by the final image divided by the angle subtended at the unaided eye by the object. It is a ratio of angles, not of sizes. [2]

A3 A concave parabolic primary mirror and a convex secondary mirror. The secondary reflects the converging light back through a central hole in the primary, to a focus just behind it. [2]

SECTION B · Standard

B1 $M = f_o/f_e = 1.5/0.030 = 50$. Length $= f_o + f_e = 1.53$ m. [3]

B2 $M = 1.0/0.025 = 40$. Angle through the telescope $= 40 \times 9.0 \times 10^{-3} = 0.36$ rad, about 21°. [3]

B3 $f_o = 60f_e$ and $f_o + f_e = 1.22$ m, so $61f_e = 1.22$ m: $f_e = 20$ mm and $f_o = 1.20$ m. Check: $1.20 + 0.02 = 1.22$ m. [4]

B4 Glass refracts blue light more than red, so each colour has a different focal length and no single sharp focus exists; images carry coloured fringes. Reflection is the same for every wavelength, so mirrors focus all colours together. [3]

B5 For a spherical surface, rays striking near the edge focus closer than rays near the axis, smearing the focus. The primary is ground to a parabola, which brings all rays parallel to the axis to a single focus. [3]

SECTION C · Stretch

C1 $M = 3.2/0.0080 = 400$. The crater subtends $400 \times 4.0 \times 10^{-5} = 0.016$ rad, easily resolved by the eye. [3]

C2 Reflector: no chromatic aberration, and the parabolic primary removes spherical aberration; a mirror can also be supported across its back, so large apertures are practical, and less light is lost than in thick glass. Refractor: a sealed tube needs little maintenance, while mirror coatings need occasional renewal. (Any two reflector points, any one refractor point.) [4]

C3 Magnification only stretches the light already collected; it can be made large with a short-focus eyepiece. Image quality depends on the objective's diameter, which sets how much light is gathered and how fine the detail that can be resolved. [2]